Living to 100 Symposium -- January 4-6, 2017

Abstracts of the Papers to be Presented by Session Number

Session 1A: Data Sources and Analysis

Paper Name: Compiling a Very Large Sample of Centenarian Pedigrees to Ascertain Patterns of Inheritance and a "Familial Propensity For Longevity Score"

Author(s): Lisa Nussbaum, Giacomo Nebbia, Annie Helmkamp, Stacy Andersen, Thomas Perls, Paola Sebastiani

Abstract:

It is apparent that a large portion of the baby boomer population will live beyond the age of 90 years. Entitlement programs and various insurance products have thusly become interested in longevity risk. Beyond period life table predictions, actuaries have little to go on in determining which individuals or portions of populations are at increased risk of living to 90 or 100 or even older. We and others have noted strong familial risk for living beyond the oldest one percentile of survival for a birth cohort. However, just because one is at increased risk, the odds of achieving such a milestone are still small if the event is very rare. We hypothesized that determining common patterns of longevity (e.g. paternal, maternal, skipping generations) and level of risk according to which of one's relatives were long-lived can help inform actuaries about longevity risk. In order to explore this hypothesis we proposed to perform network analyses of thousands of pedigrees that provide vital information for each family member. An important step of this work is to compile as large samples of pedigrees as possible with and without long lived family members. Here, we describe our process of hand-curation of centenarian pedigrees and software that we have developed for the automated construction of such pedigrees.

Paper Name: Levels and Trends in Regional Mortality in the U.S.at ages 80 and over: Exploratory Data Analysis of Direct Mortality Estimates

Author(s): Kirill Andreev, Danan Gu

Abstract:

Exploratory data analysis was performed on direct mortality estimates produced by the almost extinct cohort method for states of the United States in the period 1959-2011 and at ages 80 and over. The estimates for the 1960s produced by this method were found unreliable due to heavy age misreporting in the U.S. data on deaths. However, due to dramatic improvements in quality of the U.S. data at older ages over last four decades, the estimates for the period 2000-2011 could be accepted as reasonably good. In 2000-2011, levels of mortality in the United States were found to be very similar to average levels of mortality in 12 European high-longevity countries and Japan with the exception of Japanese females. Disparities in mortality between U.S. states were also found comparable with disparities existing in the 13 high-longevity countries. In general, mortality was lower in Western and Northeastern states and higher in Southern states. Hawaii stands out as a state with exceptionally high survival at advanced ages.

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Abstracts of the Papers to be Presented by Session Number

Session 1B: Late Life Mortality Curves

Paper Name: Mortality Trajectories at Exceptionally High Ages: A Study of Supercentenarians

Author(s): Natalia S. Gavrilova, Leonid A. Gavrilov

Abstract:

Growing number of persons surviving to age 100 years and beyond raises questions about the shape of mortality trajectories at exceptionally high ages, and this problem may become significant for actuaries in the nearest future. However, such studies are scarce because of difficulties in obtaining reliable age estimates at exceptionally high ages. Current view about mortality beyond age 110 years suggests that death rates do not grow with age and are virtually flat. The same assumption is made in the new actuarial VBT tables. In this paper we test hypothesis that mortality of supercentenarians (persons living 110+ years) is constant and does not grow with age and analyze mortality trajectories at these exceptionally high ages.

Death records of supercentenarians were taken from the International Database on Longevity (IDL). All ages of supercentenarians in the database were subjected to careful validation. We used IDL records for persons belonging to extinct birth cohorts (born before 1893) since the last deaths in IDL were observed in 2007. Also we used data for birth cohorts that did not contain censored observations.
Taking into account high variation and relatively low accuracy of hazard rate estimates after age 110 we applied more robust ways to test the assumptions about mortality distribution at advanced ages. First of all, we tested the assumption that "human mortality after age 110 is flat" (Gampe, 2010). This assumption means that mortality after age 110 years is described by a simple exponential distribution. This distribution has at least two general properties. First property is that the remaining life expectancy should be flat (does not change with age) if survival follows the exponential distribution. The second property is that coefficient of variation (CV) for remaining life expectancy should be equal to one. To test these two assumptions, we studied survival data for cohort of supercentenarians born in 1885-1892 and calculated remaining life expectancies for each quarter of age from age 110 to age 115. At age 115 years there are less than 10 persons left so we did not attempt to calculate life expectancy for this remaining small sample.

We found that the remaining life expectancy in the studied sample of supercentenarians is declining with age and this decline does not agree with the assumption about constant remaining life expectancy. The regression slope coefficient for linear regression model of life expectancy on age is negative (-0.24) and significantly different from zero ($p<0.001$). The coefficient of variation for life expectancy (CV) on age is lower than one and has a tendency to decline rather than increase with age. The regression slope coefficient of linear regression of CV on age is negative (-0.041) and not significantly different from zero (0.066). Thus more robust way to test for the assumption of flat hazard rate (constant life expectancy and CV equal to one) failed to confirm the validity of this assumption. Further analyses of mortality trajectories showed that hazard rate estimates based on age-specific death rates continue to grow after age 110 years and are compatible with the Gompertz law.

These results demonstrate for the first time that hazard rates after age 110 years do not stay constant and suggest that mortality deceleration at older ages is not a universal phenomenon. These findings may represent a challenge to the existing theories of aging and longevity, which predict constant mortality in the late stages of life. One possibility for reconciliation of the observed phenomenon and the existing theoretical consideration is a possibility of mortality deceleration and mortality plateau at very high yet unobservable ages.

Paper Name: Historical Evolution of Old-Age Mortality and New Approaches to Mortality Forecasting

Author(s): Leonid A. Gavrilov, Natalia S. Gavrilova

Abstract:

Knowledge of future mortality levels and trends is important for actuarial practice, but poses a challenge to both actuaries and demographers. Lee-Carter method, currently used for mortality forecasting, is based on the assumption that historical evolution of mortality at all age groups is driven by one factor only. This approach cannot capture an additive manner of mortality decline observed before the 1960s. In order to overcome limitation of one-factor model of mortality and to determine the true number of factors underlying mortality changes over time we suggest new approach to mortality analysis and forecasting based on the method of latent variable analysis. The basic assumption of this approach is that most variation in mortality rates over time is a manifestation of a small number of latent variables, variation in which give rise to the observed mortality patterns. To extract major components of mortality variation we apply factor analysis to mortality changes in developed countries over the period of 1900-2014.

Factor analysis of time series of age-specific death rates in 12 developed countries (data taken from the Human Mortality Database) identified two factors capable of explaining almost 94-99% of the variance in the temporal changes of death rates at ages 25-85 years. Analysis of these two factors reveals that the first factor is a “young-age” or background factor with high factor loadings at ages 30-45 years. On the other hand, the second factor can be called an “old-age” or senescent factor because of high factor loadings at ages 65-85 years. It was found that the senescent factor was relatively stable in the past but now is rapidly declining for both men and women. The decline of senescent factor is faster for men although in most countries it started almost 30 years later.

Factor analysis of time series of age-specific death rates conducted for the oldest-old ages (65-100 years) found two factors explaining variation of mortality at extremely old ages in the United States. The first factor is comparable with the senescent factor found for adult mortality. The second factor, however, is specific to extreme old ages (96-100 years) and shows peaks in 1960 and 2000. Although mortality below 90-95 years shows steady decline with time driven by the senescent factor, mortality of centenarians does not decline and remains relatively stable.

The approach suggested in this paper has several advantages. First, it is able to determine the total number of independent factors affecting mortality changes over time. Second, this approach allows researchers to determine the time interval, in which underlying factors remain stable or undergo rapid changes. Most methods of mortality projections are not able to identify the best base period for

mortality projections attempting to use the longest possible time period instead. We observe that the senescent factor of mortality continues to decline and this decline does not demonstrate any indications of slowing down. At the same time, mortality of centenarians does not decline and remains stable. Lack of mortality decline at extremely old ages may diminish anticipated longevity gains in the future.

Paper Name: Where is the Level of the Mortality Plateau?

Author(s): Roland Rau, Marcus Ebeling, Frederik Peters, Christina Bohk-Ewald, Trifon I. Missov,

Abstract:

Using data from the "International Database on Longevity", Gampe (2010) found, indeed, a plateau of mortality—which is implied in a logistic model— at ages 110 and above. In her study, Gampe pursued a nonparametric approach. Hence this plateau was not the consequence of forcing a certain parametric shape of the mortality trajectory. Gampe estimated a level of the force of mortality of $\mu(x)_{110+} = 0.7$, corresponding to a probability of dying of approximately 0.50. Gampe's results strengthened the initial findings that were reported at the "Living to 100" conference in 2005 (Robine et al., 2005).

Our research question can be expressed simply as: Can we find support for this upper limit of the force of mortality of 0.7, i.e. the chance to survive another year is approximately the chance of tossing a fair coin.

Session 2B: Older Age Mortality Trends

Paper Name: Extreme Value Analysis of Mortality at the Oldest Ages: A Case Study Based on Individual Ages at Death

Author(s): Samuel Gbari; Michel Poulain, Luc Dal, Michel Denuit

Abstract:

In this paper, the force of mortality at the oldest ages is studied using the statistical tools from extreme value theory. A unique data basis recording all individual ages at death above 95 for extinct cohorts born in Belgium between 1886 and 1904 is used to illustrate the relevance of the proposed approach. No levelling-off in the force of mortality at the oldest ages is found and the analysis supports the existence of an upper limit to human lifetime for these cohorts. Therefore, assuming that the force of mortality becomes ultimately constant, i.e. that the remaining lifetime tends to the Negative Exponential distribution as the attained age grows is a conservative strategy for managing life annuities.

Paper Name: Improvement in Late-Life Mortality and Its Impact on the Increase in the Number of Centenarians in Quebec (Canada)

Author(s): Richard Bourbeau, Mélissa Beaudry-Godin, Bertrand Desjardins

Abstract:

Rising life expectancy at birth, and in particular lower mortality at advanced ages, has led to a marked increase in the number and the proportion of centenarians, and to new records in longevity, in low mortality countries. This explosion in the numbers of centenarians has been studied in the United States (Krach and Velkoff, 1999), France (Vallin and Meslé, 2001), England and Wales (Thatcher, 2001; Dini and Goldring, 2008), Belgium (Poulain, Chambre and Foulon, 2001), Denmark (Jeune and Skytthe, 2001), Switzerland (Robine and Paccaud, 2004), Italy (Poulain et al., 2004), Japan (Robine and Saito, 2003; Robine, Saito and Jagger, 2003), Australia (Terblanche and Wilson, 2014), as well as in Europe (Robine and Saito, 2009) and the industrialized countries (Rau et al., 2008; Herm et al., 2012).

In this study the evolution of the number of centenarians in Quebec in order to determine, among other things, whether Quebec's profile resembles that observed in other low mortality countries in terms of level and trends, is analyzed. This type of analysis has not been done before in Quebec, which offers an opportunity to improve knowledge about the emergence of centenarians and about survival to advanced ages.

We chose to work on the Quebec data because they offer the best possibilities for analysis in Canada. Census data and population estimates as well as civil registration statistics are available to enable us to study this relatively new and rapidly expanding phenomenon, although imperfections in the data mean that hypotheses have to be formulated and corrections introduced to make them representative of reality. The aim of the study is to use demographic indicators such as the centenarian ratio, the probabilities of surviving and maximum age at death to give an account of the evolution of this population

over the course of the last century, and to measure its place in today's society. As a result, we will be able to identify the factors responsible for the increase in the numbers of centenarians, and to quantify their relative contributions.

Paper Name: Accuracy of Official High Age Population Estimates in England and Wales: An Evaluation

Author(s): UK Office for National Statistics, Contact Angele Storey

Abstract:
https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/ageing/methodologies/accuracyofofficialhighagepopulationestimatesinenglandandwalesanevaluation

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Abstracts of the Papers to be Presented by Session Number

Session 3A: Mortality Inequality: Impact of Socioeconomic Factors

Paper Name: Trends in the Variability of Age at Death Among the Elderly by Leading Causes of Death in Canada

Author(s): Viorela Diaconu, Nadine Ouellette, Carlo. G. Camarda, Robert Bourbeau

Abstract:

Our analysis allows identifying, firstly, the pattern of trends and differentials in the standard deviation above the mode, SD(M+), for the six leading causes of death among Canadian males and females and, secondly, the pace at which changes in the variability in the length-of-life of individuals battling any of these diseases occurred. We anticipate a higher SD(M+) values for causes that are strongly associated with health-related risk behaviors, such as smoking, alcohol consumption, physical inactivity, than causes less dependent on such behaviors. Indeed, in Canada a steeper educational and income gradient has been observed for smoking and alcohol-related diseases than any other pathogens (Tjepkema 2012, 2013). Moreover, we suspect that SD(M+) decreased for the six causes of death over the 1974-2011 period. However, we believe that the onset of the decline in SD(M+) for heart diseases and cerebrovascular diseases started earlier. Indeed, in Canada, as in many industrialized countries, the rapid and steady decline in cardiovascular mortality began around the late 1960s (Lussier et al. 2008, Ouellette et al. 2014). Reduction in death rates from these diseases have been attributed to innovations in therapeutic and surgical procedures, changes in individual behaviors (physical exercise, diet, and tobacco consumption in particular) but also to breakthroughs in pharmacological treatments. In contrast, the dominant turning point in cancer mortality trends rarely took place before the 1990s in most high-income countries (Ouellette et al. 2014). Improvements in survival to these malignant neoplasms are associated with early diagnosis and most especially with highly complex treatment techniques (chemotherapy, radiotherapy) whose success depend on individual's willingness of complying with the demanding treatment schedule. Because medical advances in cardiovascular diseases appeared well before cancers, these innovations had more time to be known and to be adopted by individuals from all different social backgrounds. Indeed, according to the diffusion process new medical technologies and healthy lifestyles behaviors are firstly adopted by high-social strata individuals and afterwards spread to the rest of the population (Link et al. 1998, Chang and Lauderdale 2008). Moreover, cardiovascular diseases can also be controlled with highly effective drug treatments which are simpler to use and to adhere than the highly complex medical treatments for cancers. For a medical breakthrough to be effectively adopted and diffused it must possess some specific attributes including lack of “complexity", that is, effortless to use (Rogers 2003). Whether or not our expectations are correct, the findings of the present study deepen our understanding on lifespan variation by leading cause by allowing an examination of changes in the shape of cause-specific SD(M+) trends as well as in the pace at which these changes occurred since the mid-1970s. Trends and levels of old-age life span variation by cause will be of great relevance to individuals and societies, more generally, as it informs on the uncertainty surrounding the age at death of individuals battling a particular disease. For individuals, the level of uncertainty in the timing of death affects their decisions regarding the level of investment in education and in health (Lee 2003, Edwards 2013) as well as their saving behaviors over the life-course (Dynan et al. 2002, Edwards 2009). From society's standpoint, uncertainty about the timing of death will be of great use in determining the minimum eligibility age at retirement (Kalemli-Oczan and Weil 2002),

forecasting costs of public pensions, as well as establishing the amount of insurance premiums and yearly annuities payments (Edwards and Tuljapurkar 2005).

Paper Name: Mortality Projections with Explicit Consideration of Behavioral Factors

Author(s): Sam Gutterman

Abstract:

Human behavior plays a significant role in mortality experience. The two primary behavioral sources assessed in this paper are the smoking and obesity epidemics. Although the smoking epidemic has been on the wane for several decades in the United States, its adverse consequence on mortality will continue to be felt for quite some time, while obesity is still on its forty year rise, with its most significant effect on mortality expected in the future.

By analyzing historical patterns of smoking and obesity prevalence and related mortality, a series of estimates of the effect of these mortality drivers and their consequential mortality have been made. The estimated decrease in cohort life expectancy for a 35 year old in 2015 due to changes in smoking and obesity of about 0.34 years for a female or a male. The estimated decrease in cohort life expectancy due to the obesity epidemic is between 0.95 and 1.41 years for females and between 1.35 and 1.85 years for males. The overall effect of changes in smoking is an increase of about 0.75 years for a female and 1.28 years for a male.

Paper Name: Causal Mortality by Socioeconomic Circumstances: A Model to Assess the Impact of Policy Options of Inequalities in Life Expectancy
Author(s): Daniel H. Alai, Séverine Arnold, Madhavi Bajekal, Andres M. Villegas

Abstract:

We investigate the relationship between socio-economic circumstances and causal mortality using a unique dataset obtained from the UK Office for National Statistics. We apply a multinomial logistic framework; the reason is twofold. First, covariates such as socio-economic circumstances are readily incorporated. And second, the framework is able to handle the intrinsic dependence amongst the competing causes. As a consequence of the dataset and modelling framework, we are able to investigate the impact of improvements in cause-specific mortality by socio-economic circumstances. We assess the impact using (residual) life expectancy, a measure of aggregate mortality. Of main interest are the gaps in life expectancy between socio-economic groups, the trends in these gaps over time, and the ability to identify the causes most influential in reducing these gaps.

Session 3B: Comparing Mortality of Different Groups

Paper Name: Longevity Greeks: What Insurers and Capital Market Investors Should Know About?

Author(s): Kenneth Q. Zhou, Siu-Hang (Johnny) Li

Abstract:

Recently, it has been argued that capital markets may share some of the overwhelming longevity risk exposures borne by the pension and life insurance industries. The transfer of risk can be accomplished by trading standardized derivatives such as q-forwards that are linked to published mortality indexes. To strategize such trades, one may utilize `longevity Greeks', which are analogous to equity Greeks that have been used extensively in managing stock price risk. In this paper, we first derive three important longevity Greeks - delta, gamma and vega - on the basis of an extended version of the Lee-Carter model that incorporates stochastic volatility. We then study the properties of each longevity Greek, and estimate the levels of effectiveness that different longevity Greek hedges can possibly achieve. The results reveal several interesting facts; for example, in a delta-vega hedge formed by q-forwards, the choice of reference ages does not materially affect hedge effectiveness, but the choice of times-to-maturity does. These facts may aid insurers to better formulate their hedge portfolios, and issuers of mortality-linked securities to determine what security structures are more likely to attract liquidity.

Paper Name: Using Life Table Techniques to Model Mortality Rates for Small Populations

Author(s): Ching-Syang (Jack) Yue, Hsin Chung Wang

Abstract:

The study of human longevity has been a popular research topic due to the prolonging life. However, the availability and quality of elderly data increase the difficulty of mortality modeling. It is particularly challenging if the size of target population is small, and the parameter estimation of stochastic mortality models can be distorted. For example, the famous Lee-Carter model (Lee and Carter, 1992) would have biased estimates for age-related parameters and in the case of small populations. In this study, we aim to provide a possible solution to deal with the parameter estimation of mortality models when the population size is small.

We propose graduation methods to modify the parameters' estimates of mortality models, similar to the process of constructing life tables where mortality rates are smoothed to remove the irregularity of some observed values. The graduation methods, including Whittaker graduation and partial SMR (standard mortality ratio), will be applied to the Lee-Carter to smooth the parameters' estimates and compared to the coherent Lee-Carter model (Li and Lee, 2005). We use computer simulation to evaluate the proposed approach and we found that it does have smaller fitting errors when the population size is small.

Paper Name: A Comprehensive Analysis of the Patterns of Worldwide Mortality Evolution

Author(s): Martin Genz

Abstract:

A variety of literature deals with the question how the age distribution of deaths develops over time, and many different notions have been established for certain scenarios. In Börger et al. (2016), a classification framework has been developed which allows for a unique classification of mortality evolution patterns. In particular, the framework assigns a unique scenario to any possible mortality evolution. In contrast to many other classification approaches, this approach allows for so-called mixed scenarios, e.g. a combination of elements of compression and shifting mortality. Thus, it provides a more comprehensive picture of historical and potential future mortality evolution patterns.

In the present paper we briefly summarize this classification framework and discuss issues in its practical application. Then, we apply the framework to mortality data for different countries all over the world. This yields a complete picture of historical mortality evolution patterns in those countries and adds to existing analyses where only certain aspects of mortality evolution patterns have been considered (e.g. a test for one scenario like compression) for only one or a few countries. We then discuss similarities and differences in the historical mortality evolution patterns between different populations. We also apply the framework to different age ranges since sometimes different scenarios can be observed for different age ranges even within one population.

Session 4A: Longevity in the Public Eye

Paper Name: The Dynamic Implications of Longevity on Health Care Cost

Author(s): Dan Bailey

Abstract:

The squaring of the life curve and the resulting aging of the population have profound ramifications on health care and its increasing overall and per capita cost. Moreover, health security and financial security are integrally related—as people live longer, they need to provide economically for more post-retirement years, including health care costs during this telescoping period; the one intensifies the other. This study will discuss the general global effects of longevity on health care costs but primarily focus on the system for the finance and delivery of health care specifically in the United States.

Paper Name: Financial Shocks, Unexpected Expenses of and Financial Experiences of Older Americans

Author(s): Anna M. Rappaport

Abstract:

The older age population is growing and will grow further as a result of longer life spans and fertility patterns. Retirement ages are not routinely adjusted to match changing life spans, and retirement plans have shifted from defined benefit to defined contribution. Many of today's retirees have defined benefit pensions, but fewer will have pensions in the future, and many people are not saving enough in defined contribution plans to provide equivalent retirement resources. There is a growing awareness of gaps in financial literacy. All of this contributes to a growing concern about how well Americans will do in old age, and about the adequacy of their retirement security. These challenges may grow even more severe over time depending on how Social Security is adjusted in light of that program's projected longer-term financial imbalance.

The Society of Actuaries' Committee on Post-Retirement Needs and Risks (CPRNR) has been working for nearly 20 years to identify and understand the way Americans manage their finances post-retirement. This work includes eight biennial surveys of the public's knowledge and perceptions about post-retirement risk management and perceptions. A major finding from this work is that planning often tends to be short term and cash flow focused, and that many people do not focus on risk or plan for shocks.

In 2015, the Society of Actuaries' retirement risk research consisted of three components – the Survey of Post-Retirement Risk and the Process of Retirement (surveying U.S. pre-retirees and retirees), focus groups looking at experiences of U.S. and Canadian individuals who had been retired 15 years of more and were resource constrained, and in-depth interviews with caregivers of people who need substantial care and would have generally fit into the focus group population.

The SOA is also working with the Social Security Administration and the University of Southern California as partners on a survey of the financial experiences of Americans. This study uses a new internet panel, the Understanding Americans Survey (UAS). This survey complements the risk survey and also includes a section on financial shocks, although they are identified somewhat differently. This 2015 survey updates the 2013 Older Americans Study that looked at the financial behaviors of older Americans.

This paper synthesizes the work on shocks from these studies and brings in additional research in order to understand more about the financial experiences of older Americans. It also includes highlights of modeling of retirement adequacy that focuses on shocks and the individual. It brings in some cumulative findings from SOA research and offers perspectives on financial management and planning for middle market segment Americans. It offers some suggestions for further research and responses to the findings.

Session 4B: Mortality Projections

Paper Name: Grouped Multivariate and Functional Time Series Forecasting: An Application to Annuity Pricing

Author(s): Han Lin Shang, Steven Haberman

Abstract:

Age-specific mortality rates are often disaggregated by different attributes, such as sex, state, ethnic group and socioeconomic status. In making social policies and pricing annuity at national and sub-national levels, it is not only important to forecast mortality accurately, but also forecasts at sub-national levels should add up to the forecasts at national level. This motivates recent developments of grouped functional times series methods (Shang & Hyndman 2016) to reconcile age-specific mortality forecasts. We extend these grouped functional time series forecasting methods to multivariate time series, and apply them to produce point forecasts of mortality rates at older ages, from which fixed-term annuities for different ages and maturities can be priced. Using the regional age-specific mortality rates in Japan obtained from the Japanese Mortality Database, we investigate the one-step-ahead to 15-step-ahead point forecast accuracy between the independent and grouped forecasting methods. The grouped forecasting methods are not only shown to be useful for reconciling forecasts of age-specific mortality rates at national and sub-national levels, but they also enjoy improved forecast accuracy. The improved forecast accuracy of mortality rates would be of great interest to the insurance and pension industries for estimating annuity prices, in particular at the level of population subgroups, defined by key factors such as gender, region, socio-economic grouping.

Paper Name: Mortality Improvement Rates: Modelling and Parameter Uncertainty

Author(s): Andrew Hunt, Andres M. Villegas

Abstract:

Rather than looking at mortality rates directly, a number of recent academic studies have looked at modelling rates of improvement in mortality when making mortality projections. Although relatively new in the academic literature, the use of mortality improvement rates has a long-standing tradition in actuarial practice when allowing for improvements in mortality from standard mortality tables. However, mortality improvement rates are difficult to estimate robustly and models of them are subject to high levels of parameter uncertainty, since they are derived by dividing one uncertain quantity by another. Despite this, the studies of mortality improvement rates to date have not investigated parameter uncertainty due to the ad hoc methods used to fit the models to historical data. In this study, we adapt the Poisson model for the numbers of deaths at each age and year, proposed in Brouhns et al. [Insurance: Mathematics and Economics 3 (2002) 31] to model mortality improvement rates. This enables models of improvement rates to be fitted using standard maximum likelihood techniques and allows parameter uncertainty to be investigated using a standard bootstrapping approach. We illustrate the proposed modelling approach using data for the USA and England and Wales populations.

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Abstracts of the Papers to be Presented by Session Number

Paper Name: On the Heterogeneity of Human Population as Reflected by the Mortality Dynamics

Author(s): Demetris Avraam, Séverine Arnold, Olga Vasieva, Bakhtier Vasiev